# The Effect of Backward Priming on Word Recognition in Single-word and Sentence Contexts.

Robert R. Peterson

# The Effect of Backward Priming on Word Recognition in Single-word and Sentence Contexts

A Thesis

Presented to the

Department of Psychology

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

University of Nebraska at Omaha

by

Robert R. Peterson

July, 1986

THESIS ACCEPTANCE

Accepted for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha.

Committee

| Name | Department |
|---|---|
| Kenneth R. Deffenbacher | Psychology |
| Wayne Harrison | Psychology |
| Thomas C. Lombard | Special Education |
| | |

Gregory R. Simpson
Chairman

July 25, 1986
Date

## Acknowledgements

I would like to thank the members of my committee: Dr. Ken Deffenbacher, Dr. Wayne Harrison, Dr. Tom Lorsbach, and Dr. Greg Simpson. Their insightful comments on, and criticisms of, this project undoubtedly resulted in a thesis of much higher quality.

I am particularly indebted to Dr. Greg Simpson, who served both as the chairman of my committee and as my advisor. Upon entering graduate school, my academic interests lacked focus, and it was primarily my collaboration with Greg that gave direction to my studies, and which allowed me to begin setting goals for my future career.

In addition, I would like to thank two fellow graduate students who have played a important role in my graduate school experience. The first is John Klaric, who has, over the past two years, become a very good friend. John and I have spent numerous hours discussing research ideas, as well as contemplating the anxieties and joys of graduate school life. The second student is Curt Burgess, who is both a former and a future colleague. Curt's enthusiasm towards research is infectious, and it is largely because of him that I have developed a passion for my own work. I look forward to future collaborations with him, and am sure that they will be immensely fruitful.

Finally, and most importantly, I wish to thank my family. The caring and support given to me by my parents underlie any success I have ever had, either academically or personally. I have wrongly failed to acknowledge this fact in this past, so I hope that this present acknowledgement serves to rectify my past neglect. My wife, Teresa, has been remarkably patient and understanding, and she has been the person to whom I have been able to turn for comfort. Finally, a loving thanks goes to my son, Jimmy, who, with his smile alone, has been able to ease greatly my burden.

Table of Contents

## Abstract

Backward priming was investigated under conditions similar to those found in lexical ambiguity research. Subjects received prime-target word pairs which were associated either in a backward direction (BABY-STORK) or bidirectionally (BABY-CRY). The primes were auditorily presented, either in isolation or in a sentence, and subjects made lexical decision or naming responses to the targets, which followed the primes either immediately or after 200 msec. Forward priming was obtained in all conditions. Backward priming occurred with both response tasks, but only when the prime was an isolated word. For naming only, backward priming decreased over time. The results suggest that the locus of the backward priming effect is different for naming and lexical decision. Further, there was no evidence to support the claim that backward priming can account for the demonstrations, in the ambiguity literature, of priming for contextually inappropriate meanings of ambiguous words in sentence contexts.

The Effect of Backward Priming on Word Recognition in Single-word and Sentence Contexts

There has been, over the past decade, a great deal of effort devoted to the task of discovering the processes underlying the comprehension of ambiguous words (e.g., Forster & Bednall, 1976; Foss, 1970; Glucksberg, Kreuz, & Rho, 1976; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). Of primary concern in this literature is the extent to which context can influence the retrieval of the different meanings associated with these words. For example, in the Sentence 1:

1) The businessman walked into the bank.

the final word (BANK) is ambiguous since it can refer either to a financial institution or to the body of land along a river. In this sentence, however, the financial sense of BANK is presumably intended. Of interest, then, is how this contextual bias affects the availability of the different meanings of BANK, and in particular the meaning which is contextually inappropriate (i.e., the river meaning). One possibility is that the context is able to constrain lexical access such that only the monetary meaning of BANK is retrieved (Schvaneveldt, Meyer, & Becker, 1976; Simpson, 1981). Models which have posited such a direct influence of context on meaning retrieval have been referred to as context-dependent models of lexical access (Simpson, 1984). Context-independent models (Simpson, 1984), on the other hand, posit that the lexical processor is functionally autonomous from higher level language processors (such as those computing the syntactic and semantic structures of a message) and thus is impervious to such contextual constraints (Forster, 1979). One possible implication of this position is that, regardless of the context, all meanings of an ambiguous word are accessed immediately following the presentation of that word (Onifer & Swinney, 1981; Seidenberg et al., 1982; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979). This model further postulates that, following lexical access, the multiple meanings are rapidly compared to the context, with the appropriate meaning being selected for further processing (and being made available to consciousness), while inappropriate meanings are in some manner discarded. Thus, the critical difference between the two models (the context-dependent and the context-independent models) is the point in time when context is postulated to exert its effect on processing. In a context-dependent model, context is seen to have an early effect, directly influencing the meaning of the ambiguous word which is retrieved. The context-independent model postulates that context only affects selection processes which occur after lexical access per se.

Because these models make very specific predictions, and because these predictions are mutually exclusive, the task of empirically testing them would seem to be a relatively straightforward endeavor. Unfortunately, however, the development of an adequate methodology with which to make this test has been somewhat problematic. A methodology is needed which is highly sensitive to the activation level of the meanings of an ambiguous word during normal language comprehension, and, further, which is able to detect changes in these activation patterns over time (Seidenberg & Tanenhaus, in press). Many of the early methodologies which were employed, however, failed to meet these requirements. As a result, the evolution of ambiguity research has been as much a matter of eliminating inappropriate techniques as it has been a matter of explicating the processes underlying ambiguity resolution (see Simpson, 1984, for a review of these various techniques). However, it has been argued that there is one general set of techniques (semantic priming tasks) that does, in fact, contain the necessary characteristics for adequately testing these models (e.g., Seidenberg et al., 1982). Because of the important role that semantic priming tasks have played in the development of the ambiguity literature, it is worthwhile to review the nature of these tasks, their theoretical underpinnings, as well as logic behind their application to the ambiguity research.

<u>Semantic priming tasks and lexical ambiguity</u>

In semantic priming tasks, subjects are typically presented with two words in succession (referred to as the "prime" and the "target", respectively) and are instructed to respond rapidly in some fashion to the target, with the latency to this response being the primary measure of interest. The exact nature of this response varies across specific paradigms. For example, subjects may be asked simply to name the word out loud (naming task), or ,rather, to decide if the target item is in fact a word (lexical decision task). It is a common finding, for both of these tasks, that the response latency to the target is shorter when the prime and target are related than when they are not (e.g., Meyer & Schvaneveldt, 1971). That is, a subject is quicker to name the word BUTTER (or decide that it is a word) when it follows the word BREAD than when it follows CHAIR. This difference in response time between related and unrelated trials is referred to as the "priming effect."

In order to account for this effect, theorists generally have relied on the concept of "spreading activation." For example, in the Collins and Loftus (1975) model, semantic memory is envisioned as being a network-like structure, with concepts being represented as the nodes in the network. Recognition of a word involves "activating," above some threshold value, the node corresponding to the conceptual representation of that word. Activation is said to spread passively from this node along connecting pathways to other conceptually related nodes, with the amount of activation arriving at any specific node being dependent on its strength of association with the originally activated concept. This spread of activation has the effect of momentarily raising the level of activation at these related nodes. Should a word corresponding to one of these related concepts be presented, recognition of it will occur more quickly than normal since less activation would be required to accumulate at its node to reach threshold.

Priming tasks, thus, seem to be sensitive to the pattern of activation occurring at any point in time in the semantic network (but see Lupker, 1984). This quality makes them highly desirable for use in lexical ambiguity research, since they should, theoretically at least, be able to reveal the level of activation, over time, for each of the meanings of an ambiguous word. Because of this characteristic, these tasks presumably can be used to test directly context-dependent and context-independent models of ambiguity resolution. That is, if context is able to constrain the access of meaning for ambiguous words such that only the contextually appropriate meaning is retrieved (context-dependent model), then following the presentation of an ambiguous word, one should only obtain priming for target words related to that single meaning. Hence, for Sentence 1 listed above, if a context-dependent model is indeed correct, one would expect a faster response to a target word like MONEY (a contextually appropriate target) than to CHAIR (an unrelated target). However, for the target RIVER (a contextually inappropriate target) there should be no priming, since, according to a context-dependent model, this meaning is never activated. If, however, all meanings of an ambiguous word are accessed immediately following the presentation of the ambiguous word (context-independent model), then one should observe priming for target words related to all those meanings. Hence, for Sentence 1, priming should obtain for both MONEY and RIVER when those targets are presented immediately following the ambiguous word BANK.

Researchers who have used semantic priming tasks have found, with a fair degree of consistency, that when the target is presented immediately following the ambiguous word, responses to targets related to either meaning of the ambiguous word are faster than responses to an unrelated control (Kintsch & Mross, 1985; Onifer & Swinney, 1981; Seidenberg et al., 1982; Swinney, 1979; Tanenhaus et al., 1979). The researchers have concluded, based on this result, that there is an exhaustive access of the meanings of ambiguous words immediately following their presentation (thus supporting a context-independent model). An important point to be made here, however, is that this conclusion logically follows from the data only if it is assumed that priming for the related targets is a result of activation which has spread from the meanings of the ambiguous word to their related concepts. If however, the spreading activation assumption underlying semantic priming tasks is incorrect, then exhaustive access conclusions may be quite unwarranted.

Koriat (1981) has, in fact, questioned the spreading activation account of priming effects. He notes that, since activation is said to spread <u>from</u> the prime <u>to</u> the target, the amount of priming that is obtained in a semantic priming task should be dependent only on the strength of association from the prime to the target (and, hence, should be unrelated to the degree of association from the target to the prime). To test this assertion, Koriat (1981) conducted a priming experiment, using a lexical decision task, in which, for related trials, he used pairs of words which were associated in a single direction only. An example of such a pair are the words STORK and BABY. While BABY is a strong associate of STORK (i.e., in association norms, BABY is a frequent response to the stimulus STORK), there is little association between these words in the opposite direction (i.e., STORK is rarely given as a response to the word BABY). If a spreading activation view is correct, then one would expect priming when STORK serves as the prime and BABY as the target, but not in the reverse order (BABY as the prime and STORK as the target). However, Koriat found, using a 550 msec delay from the onset of the prime to the onset of the target (stimulus onset asychrony, or SOA), equivalent amounts of priming for both orderings. Based on this finding, he concluded that there may be two independent priming effects: one operating in a forward direction from the prime to target (thus accounting for priming when an association exists from the prime to the target, e.g. STORK-BABY), and the other in a backward direction from the target to prime (accounting for priming when an association exists only from the target to the prime, e.g. BABY-STORK).

It is the existence of this backward priming effect which is particularly damaging to a spreading activation account of priming effects, since such an account has no way of explaining how recognition of a target is facilitated when there is no association (and hence no spread of activation) from the prime to the target. In trying to explain this effect, Koriat (1981) argued that the target, after it is presented, reactivates the prime and is then processed in the presence of (and in parallel with) that prime. This allows a relationship to be established between the prime and the target, leading to facilitation in recognizing the target. Unfortunately, Koriat is vague in both explaining how this "reactivation" process occurs, and in specifying a mechanism through which it can facilitate the processing of the target.

Despite this lack of clarity, Koriat's results are nevertheless quite important because they demonstrate a priming effect which cannot be accounted for by a spreading activation mechanism. His results, therefore, pose a threat to any body of research which has rested its interpretations solely on a spreading activation assumption. Koriat suggests that the lexical ambiguity literature, in particular, is quite vulnerable to this threat. He specifically argues that, in this research, it is possible that <u>only</u> contextually appropriate meanings are initially retrieved upon encountering ambiguous words, leading to forward priming of appropriate targets. The priming which has been demonstrated for unbiased targets may be occurring, Koriat (1981) contends, only after the presentation of the targets themselves, through a backward priming process. This interpretation differs, obviously, from the general conclusions which have been drawn in the ambiguity literature. Koriat's view suggests that lexical access may be context-dependent, rather than independent, with only the appropriate meaning being activated as a result of processing the ambiguous word. Activation of the inappropriate meaning, since it occurs only after the presentation of a target word, might best be thought of as an artifact of the semantic priming methodology.

Seidenberg, Waters, Sanders, and Langer (1984) have recently argued, however, that backward priming effects occur only with a lexical decision task. They claim that other semantic priming tasks, such as word-naming, are insensitive to such relationships. The critical difference between a lexical decision task and a naming task is that, in a lexical decision task, subjects not only have to retrieve a lexical item, but they further have to recognize the fact that a lexical entry has, indeed, been located. Seidenberg et al. (1984) argue that this decision might well be influenced by information which is derived after lexical access per se has occurred. With specific regard to backward priming, Seidenberg et al. (1984) suggest that subjects, after recognizing the target, may notice the backward relationship between the target and the prime, and may use the existence of this relationship as the basis for deciding that the stimulus is a word (since non-words will not form relationships with the prime). While this strategy is quite efficient for related items, unrelated targets are somewhat problematic. Since these (by definition) do not form relationships with the prime, subjects must base their decisions for these targets solely on the knowledge that lexical access has occurred. If access of such information is generally slower in reaching a decision-making processor than is relational information (Forster, 1979), then the result of these differential decision processes will be an observed backward priming effect. This effect occurs, however, during post-access decision processes, not during lexical retrieval processes per se (as implied by Koriat, 1981).

To provide evidence for this position, Seidenberg et al. (1984), like Koriat (1981), presented subjects with asymmetrical associates, in both a forward and backward direction, using a 500 msec SOA between the prime and target. Unlike Koriat (1981), however, Seidenberg et al. used both naming and lexical decision tasks. When the response was a lexical decision, Seidenberg et al. found both forward and backward priming effects (replicating Koriat, 1981). However, when a naming task was used, only facilitation for forward associates was obtained. Since naming tasks and lexical decision tasks are thought to be equally sensitive to patterns of lexical activation (Seidenberg et al., 1984), this lack of a backward priming effect with a naming task suggests that backward priming in the Koriat (1981) study may have been a result of decision-level processes occurring with the lexical decision task. Based on these results, Seidenberg et al. (1984) argue that backward priming can account for context-independent results (exhaustive access) only in those studies in the ambiguity literature which have used a lexical decision task. For those studies which have used a naming task, and which have found exhaustive access effects (Seidenberg et al., 1982; Tanenhaus et al., 1979), Seidenberg et al. (1984) conclude that a context-independent interpretation is quite valid.

Unfortunately, however, the conclusions drawn by Seidenberg et al. seem to be somewhat premature. The problem is that Seidenberg et al. generalize their results to a body of literature (the ambiguity studies) which is in many ways different from their own research. Therefore, the extent to which their generalizations are justified is unclear. Because of the seriousness of this problem, the discussion will now turn to a more detailed review of the ambiguity literature in an attempt to highlight those differences which potentially pose the greatest threat to the Seidenberg et al. conclusions.

Lexical amiguity research

As previously noted, semantic priming tasks have been, overall, very supportive of a context-independent model. Using a lexical decision task, and a cross-modal form of presentation (in which sentences were presented to subjects auditorily with targets presented visually), Swinney (1979) found facilitation for targets related both to contextually appropriate and contextually inappropriate readings of an ambiguous word. However, this result occurred only when the target immediately followed the termination of the ambiguous word. When the target was delayed by three syllables, Swinney (1979) found facilitation only for the target related to the contextually appropriate meaning. Based on this result, he argued that all meanings of an ambiguous word are initially accessed, with the correct meaning being chosen during a post-access selection process. Kintsch and Mross (1985) found similar results using an all-visual presentation technique. In one condition in their study, sentences were presented to subjects one word at a time at a rate of 190 msec per word. Subjects made lexical decisions to targets, which were always the first item following the presentation of an ambiguous word (hence there was a 190 msec SOA between the ambiguous word and the target). Kintsch and Mross found that, under these conditions, all meanings of an ambiguous word were activated regardless of the context. However, when a self-paced presentation was used (where subjects pressed a space bar to bring up each word in the sentence), Kintsch and Mross found priming for the appropriate meaning only. The rate of this self-paced presentation tended to be slower than the 190 msec experimenter-controlled rate, thus lengthening the delay between the onset of the ambiguous word and the target (although Kintsch and Mross didn't record these latencies, they estimated them to range between 300 and 500 msec). Overall, then, Kintsch and Mross's data suggest that there is an initial exhaustive access of the meanings of an ambiguous word, followed by a rapid selection process.

Using a naming task, researchers have reported similar results (Seidenberg et al., 1982; Tanenhaus et al., 1979). Tanenhaus et al. (1979) used noun-verb ambiguities with syntactically disambiguating contexts (e.g. "She held the rose" versus "They all rose"). Using a cross-modal form of presentation, they found that, regardless of the context, words associated to either meaning were named faster than unrelated words when the target was presented immediately following the offset of the ambiguous word (a 0-msec inter-stimulus interval or ISI). With an ISI of 200 msec, however, only the contextually appropriate target showed facilitation. Seidenberg et al. (1982), using noun-noun, as well as noun-verb, ambiguities, and using the same time parameters as Tanenhaus et al. (1979), found the same results (exhaustive access at a 0 msec ISI, selective at an ISI of 200 msec).

Even results which had at first been reported as support for a context-dependent model, have since been re-interpreted as being supportive of a context independent model. For example, Simpson (1981) found that when sentences were strongly biased toward one meaning of an ambiguous word, then only a word related to that meaning showed priming in a lexical decision task. Simpson (1981) argued, based on this finding, that a strongly biased context can constrain access such that only the contextually appropriate meaning is activated. However, Simpson used a 120 msec delay between the ambiguous word and the target. It has been suggested (Onifer & Swinney, 1981) that, because of this delay, Simpson's results may reflect the output of post-access selection processes rather than lexical processes per se. Hence, Simpson's results can be taken as indirect support for a context-independent model, with the implication being that the selection stage operates within

120 msec.

Overall, then, the data seem to converge reliably on the following scenario: When subjects are comprehending some form of text (such as sentences) and they encounter an ambiguous word, all possible meanings of the ambiguous word will be initially retrieved, regardless of the bias of the preceding context. However, within 200 msec following the ambiguous word (and possibly within 120 msec) the contextually appropriate meaning will be selected for further processing, with a concurrent loss of activation for inappropriate meanings.

If an argument is to be made regarding the role that backward priming might play in the above scenario, then it is necessary that one test for backward priming effects using the same conditions that are found in the ambiguity studies. Comparing the Seidenberg et al. (1984) and Koriat (1981) studies to this research, however, makes it clear that neither study is adequate for establishing a relationship (or lack thereof) between backward priming and exhaustive access. This inadequacy stems largely from the fact that the Seidenberg et al. and Koriat studies differ markedly from the ambiguity research on two specific dimensions. First, both studies test for priming effects at an SOA of about 500 msec (a relatively long delay), yet exhaustive access has been shown to dissipate well before this point in processing. Further, both studies use single, isolated words as primes, yet in the ambiguity literature (at least for those studies investigating context effects), the prime (i.e. the ambiguous word) is embedded in a sentence context. It is to the consideration of these two variables that the discussion will now turn. Two aspects of this upcoming discussion should be noted, however. First, the discussion of these variables will be necessarily speculative. This is primarily due to the fact that very little research has examined backward priming per se, hence it is difficult to judge the precise impact that these variables might have on the backward priming effect. Second, because the actual relevance of the two variables could depend on whether backward priming is a reflection of access or a post-access effects, the variables will be discussed for each possible locus of effect separately.

Backward priming as a lexical access effect

Seidenberg et al. (1984), based on their finding that backward priming effects do not occur with a naming task at an SOA of 500 msec, proposed that lexical access of a target is uninfluenced by a backward relationship from the target to a prime. However, this conclusion ignores the possibility that there may be a brief period of time, following the presentation of the prime, during which the target must be presented in order for a backward relationship to affect the access of the target.

Kiger and Glass (1983) have, in fact, provided some evidence which suggests that such a critical period may indeed exist. In their study, subjects were presented with two words in succession, but, contrary to typical priming experiments, the subjects made a lexical decision to the first word of the pair (that is, the target preceded the prime). Kiger and Glass found that when the second word followed the first by 65 msec, responses to the first word were faster when the two words were associated than when they were not. At an SOA of 130 msec, however, there was no significant priming for the target. To explain these results, Kiger and Glass (1983) argued that when the prime is presented before lexical access has occurred for the target, the prime and target are processed in parallel. This allows activation to spread backward from the prime (the second stimulus presented) to the target (the first stimulus) as well as in the reverse direction (from the target to the prime), thereby mutually facilitating both the prime and the target. However, when the prime is presented after lexical access has occurred for the target, then, obviously, it can no longer influence the retrieval of that target, and no priming is evidenced. Thus, they argue that backward priming occurs when the length of the delay between the prime and target is less than the time required for lexical access for the first stimulus of the pair (the target in this case). Although the time required for lexical access is not precisely known, independent estimates of this time have included 150 msec (Balota & Chumbley, 1985) and 183 msec (Sabol & DeRossa, 1976). Notice that these two estimates are at least fairly consistent with the 130 msec reported by Kiger and Glass.

Unfortunately, however, two aspects of the Kiger and Glass (1983) study make it unclear whether it can be directly applied to the question of backward priming in the ambiguity literature. First, Kiger and Glass used a lexical decision task, hence their results are conceivably predicated upon decision processes; their results might not obtain if a naming task were used. A second problem is the fact that Kiger and Glass use the term "backward priming" in a slightly different way from other researchers. While Koriat (1981) refers to backward priming as the facilitation in recognizing a target which <u>follows</u> a prime (as a function of an association from that target back to the prime), Kiger and Glass discuss backward priming as the facilitation for a target which <u>precedes</u> a related prime. Thus, while Kiger and Glass provide evidence which suggests that, in a priming experiment, the second stimulus can facilitate the processing of the first, they do not demonstrate that this backward facilitation can then actually influence the processing of that second stimulus itself (the claim made by Koriat). It is critical, therefore, to test directly whether such an effect can actually occur, and, further, to determine the extent to which this facilitation might be sensitive to the temporal relationship between the prime and the target.

Recall that, in addition to the delay between the prime and the target, another variable of interest is whether the prime appears in isolation or, rather, is embedded in a sentence context. There seems to be no _a priori_ reason to suspect that this variable would influence the time required for lexical access of the target per se. For example, in the ambiguity literature, it does not make sense to argue that the contextually inappropriate target receives activation simply because it was preceded by a sentence context. However, it has been argued that the nature of the prime might influence post-access processing of the target (Forster, 1981). The following section will describe means by which such post-access effects could result in backward priming.

_Backward priming as a post-access effect_

The arguments to be made here are all predicated on the assumption that backward priming is not a lexical access effect per se, but rather is a reflection of processes which occur after the access of the target word. As previously noted, Seidenberg et al. (1984) have suggested one post-access process which appears to be highly sensitive to backward relationships between the prime and target---the decision process in the lexical decision task. As Seidenberg et al. point out, however, if backward priming is to account completely for exhaustive access results in the ambiguity literature, then it must be shown that naming tasks are likewise sensitive to backward priming. In terms of the current discussion, the question is whether, with a naming task, there are any post-access processes which can be influenced by a backward relationship between a prime and target, and which can themselves influence naming latencies.

While researchers have generally regarded naming tasks as being less sensitive to post-access influences in comparison to lexical decision tasks (Seidenberg et al., 1984; West & Stanovich, 1982), it is nevertheless clear that they are not entirely free from post-access contamination (Balota & Chumbley, 1985). For example, researchers have demonstrated inhibition in the time to name a word when the word is incongruous with its preceding context (Forster, 1981; Masson, 1984, Simpson, Peterson, Casteel, & Burgess, 1985; West & Stanovich, 1986). To explain this inhibition effect, Forster (1981) has argued that when a target word appears in a sentence context, there is an obligatory attempt to integrate the word with that context. This integration actually interferes with the execution of the naming response itself. With words compatible with the prior context, integration proceeds rapidly enough to provoke little interference. With anomalous words, however, naming times are seriously delayed during a fruitless attempt at integration. It is possible that target words in lexical ambiguity studies are also subject to these integrative processes (despite the fact that they are not part of the context itself). If they are, then presumably <u>all</u> targets (contextually appropriate, contextually inappropriate, and unrelated targets) receive some interference since they are all, in some respect, incompatible with ongoing sentence processing (e.g., they are not direct syntactic continuations of the sentence). Of interest here, then, are the factors which might influence the extent of interference which occurs. One possibility is that the discovery of a relationship between the target and context might be sufficient to reduce the interference, leading to shorter response latencies. If so, then the discovery of a backward relationship between the target and ambiguous word might be likely to have such an interference-reducing effect. This argument suggests, therefore, that backward priming may be a by-product of obligatory integrative processes which occur following lexical access of the target. It should be noted, however, that this argument in no way denies that, for lexical decision tasks, there are additional, decision-based backward priming effects. This argument simply postulates an alternative source for these effects, and, in particular, one to which naming latencies might be sensitive.

One apparent problem with the integration argument presented so far, however, is that it is unable explain why exhaustive access is found only for a short time following the presentation of an ambiguous word. This effect can be explained, however, if it assumed that a delay prior to the presentation of the target allows the ambiguous word itself to be fully integrated with its context before the target word appears. In such a situation, it may be much more difficult (and much more time-consuming) to recognize a relationship between a contextually inappropriate target and the ambiguous word, thereby making it less likely that this relational information could influence a subject's response. This explanation is quite compatible, in fact, with Kintsch and Mross's (1985) delay paradigm. Recall that as a delay, they had subjects advance the presentation of a sentence by pressing a space bar to bring forth the next word. If subjects bring up the target word only after integrating the ambiguous word, then it may be this integration which blocks backward priming (and, hence, exhaustive access) from occurring.

This argument, in addition, can resolve an apparent discrepancy which exists between results reported by Seidenberg et al. (1984) and those reported by numerous ambiguity studies (e.g., Kintsch & Mross, 1985; Onifer & Swinney, 1981; Swinney, 1979). Specifically, Seidenberg et al. found backward priming with a lexical decision task at an SOA of 500 msec, although, in the ambiguity studies, there is no evidence of exhaustive access at delays of this length. Since Seidenberg et al. used single words as primes, it might have been the lack of a context with which the primes could be integrated that allowed backward priming to persist in their study across a relatively long delay interval.

In summary, there seem to be legitimate reasons for suspecting that generalizations made from the Seidenberg et al. data to the ambiguity literature might be quite misleading. The fact that Seidenberg et al. used a long delay interval makes it impossible to discern whether backward priming might occur at shorter delays. Since it is _only_ at short delays that exhaustive access effects are found, it seems critical to test for backward priming effects at these delays. In addition, the use by Seidenberg et al. of single-word primes fails to address whether backward priming might result from obligatory integrative processes which are invoked when sentence stimuli are used. Since ambiguity studies have generally used sentence stimuli, it is again unclear whether Seidenberg et al.'s conclusions can be legitimately applied to the ambiguity literature. It was a general goal of the present research to add clarity to some of these issues.

## _Objectives of the present research_

The primary purpose of this research was to determine whether backward priming occurs in those situations which have been shown to lead to exhaustive access of the meanings of ambiguous words. If backward priming can be shown to occur in these situations, then the validity of the conclusions regarding the context-independent nature of lexical access would be seriously jeopardized. In addition, this research attempted to specify the conditions necessary for the occurrence of backward priming, with the hope of using this information to determine the locus of backward priming effects.

In this research, half of the subjects were auditorily presented with a sentence such as Sentence 2:

2) The presence of the stranger upset the baby

while the other half of the subjects heard only the terminal word of the sentence (i.e. BABY). This terminal word will be, from this point on, referred to as the "prime." Following this prime, either at an ISI of 0 msec or 200 msec, subjects were shown a target, to which they made either a lexical decision or a naming response. The target was either related to the prime in a forward direction (from the prime to the target, e.g. CRY), related in a backward direction only (from the target to the prime, e.g. STORK), or was totally unrelated to the prime (e.g. CHAIR). Notice that the relationships between the prime and the various targets in this study effectively parallel the relationships that should, according to a context-dependent model, exist between the ambiguous word and the various related targets used in the ambiguity literature (i.e. contextually appropriate and contextually inappropriate targets). That is, a context-dependent model specifically argues that only contextually appropriate targets should receive forward activation from the ambiguous word. This is mimicked in the present study by using targets related to the prime in a forward direction (e.g. CRY). A context-dependent model further argues that contextually inappropriate targets receive no forward priming from the ambiguous word (since the inappropriate meaning of the ambiguous word is never retrieved). Any priming which is found for these targets must be, according to this model, backward priming. This is represented in the present study by targets which are associated to the prime in a backward direction only (such as the word STORK in the example given above). If, in the present study, priming is found for these latter targets, this would imply that the priming was due to the existence of the backward relationship. Because the materials were designed such that they mimick a context-dependent view, this finding would imply that even if a context-dependent model were correct, semantic priming tasks might nonetheless yield data consistent with a context-independent position.

In addition, by noting the variables with which the backward priming phenomenon interacts, it will be possible to gain insight into the locus of these effects. Thus, if backward priming reflects a decrease in the time required for access of related targets, then one should expect to find, given the arguments made earlier, backward priming at a 0 msec ISI only (since it is at this delay that processing of the prime and target would be likely to overlap, Kiger & Glass, 1983), regardless of both the type of task (lexical decision or naming) and the form of the prime (an isolated word or a word embedded in a sentence). On the other hand, if backward priming is solely a result of decision processes occurring with a lexical decision task (Seidenberg et al., 1984), then backward priming should occur only with this task (and not with a naming task). Finally, if backward priming effects occur as a result of obligatory integrative processes, then one would expect to find evidence of backward priming with a naming task as well, but only when the primes are embedded in a sentence context (where integrative processes would be occurring).

## Method

### Subjects

One hundred twenty-eight undergraduate volunteers from the University of Nebraska-Omaha served as subjects, and received class credit for participation. Subjects were randomly assigned to one of the four groups which resulted from the factorial crossing of the variables correponding to type of task (lexical decision and naming) and form of the prime (single-word and sentence).

### Stimuli

Sixty-four word triads were constructed. One of the words of each triad served as the prime in the experiment. The other two words were used as targets, and are distinguished from one another on the basis of their relationship to the prime. One target (the backward associate) is related to the prime in a backward direction only (from the target to the prime), while the second target (the forward associate) is related to the prime in a forward direction (from the prime to the target). For example, one triad in the set of 64 consists of the words BABY-STORK-CRY. BABY is the prime for this triad, STORK is the backward associate, and CRY is the forward associate. It should be noted that the forward associate is actually a bidirectional associate, since it tends to be related to the prime in a backward direction as well. However, this target will nonetheless be referred to as a "forward associate" since it is the existence of the forward relationship which is of interest in this study, and which most clearly distinguishes it from its backward counterpart.

Sets of association norms (Palermo & Jenkins, 1964; Postman & Keppel, 1970; Shapiro & Palermo, 1968) were used, where possible, to verify the associative relationships between the targets and the prime within each triad. This involved demonstrating, first, that when a backward associate served as a stimulus item in a set of association norms, the prime was a frequent response to it. Second, it had to be shown that when this prime was used as a stimulus, the forward associate was a frequent response, while the backward associate was rarely, if ever, given. In terms of the above example, Marshall and Cofer (1970) used STORK as a stimulus word, and found that BABY was the primary response given to this word by subjects. On the other hand, Palermo and Jenkins (1964) used BABY as a stimulus item and found that the primary response was CRY, while STORK never occurred as a response.

Unfortunately, the use of association norms failed to yield a sufficient number of stimulus triads. The reason for this shortage can largely be attributed to the fact that unidirectional associates are fairly rare. In addition, however, the procedure outlined above greatly reduced this limited number of stimuli since it required that, for a given triad, <u>both</u> the prime and backward associate appear as stimuli in at least one set of norms. Often, however, both weren't available. For example, Marshall and Cofer (1970) used MOSQUITO as a stimulus item to which BITE was the primary response. Intuitively, at least, it seems that if BITE were used as a stimulus word, MOSQUITO would be an infrequent response (thus making MOSQUITO an acceptable backward associate). Unfortunately, no set of association norms used BITE as a stimulus item, hence, a direct test of its acceptability is impossible to make. Because of these limitations, is was necessary to create many triads using intuition regarding the associative relationships among the words (although for some of these, such as the BITE-MOSQUITO example, partial information was available).

In addition to these 64 triads, 64 prime-nonword pairs were created to serve as nonword filler trials for the lexical decision task. These additional primes were selected to be similar to the original primes in both length and printed frequency (Kucera & Francis, 1967). The nonwords were created by changing one letter in each of a set of 64 words, insuring, however, that the resulting letter strings were all pronounceable.

In order to establish that these stimuli are comparable to those used by Seidenberg et al. (1984), a single-word priming study was conducted in which the stimulus pairs consisted of both unidirectional associates (the prime and backward associate) and bidirectional associates (the prime and the forward associate). This study found that when a naming task and a 500 msec SOA were used, priming was obtained for unidirectional associates when there was a forward relationship between the pair of words (e.g. STORK-BABY). However, when the ordering of the stimuli was reversed so that there was a backward relationship between the words (e.g. BABY-STORK), no priming was found. For bidirectional associates, priming was obtained regardless of the order of presentation of the words (i.e. for both BABY-CRY and CRY-BABY). The above pattern of results did not occur, however, when a lexical decision task was used. For this task, priming was obtained both for unidirectional and bidirectional associates, regardless of the ordering of the words. The difference between the two tasks, then, was that the lexical decision task demonstrated backward priming, while the naming task did not. This replicates the finding of Seidenberg et al. (1984), and suggests that, at an SOA of 500 msec and with single word primes, backward priming is an effect which is specific to the lexical decision task. The above results are also important because they provide evidence that the stimuli are indeed appropriate for use in the present study. That is, these priming data verify the relationships among the primes and targets which were established when the stimuli were created.

For each of the 128 primes, a sentence was written which ended with the prime word (see Appendix C for a listing of the stimuli). The sentences were constructed such that the mean number of words in the sentences were approximately equal for word and nonword trials. In addition, for those primes which are associated with two "word" targets (as opposed to a nonword target), sentences were written such that only the forward associates were related to the general meaning of the sentence. For example, the sentence corresponding to the BABY-STORK-CRY triad is "The presence of the stranger upset the baby." The forward associate (CRY) is more related to the general meaning of the sentence than is the backward associate (STORK). The reason for having established these relationships between the targets and the sentential meaning is that these same relationships exist in lexical ambiguity studies. For example, in Sentence 1 presented earlier, the contextually-appropriate target MONEY is related both to the ambiguous word in a forward direction, and to the sentence as a whole (hence is similar to forward associates in the present study). The inappropriate target, RIVER, however, is unrelated to the context, and, if a context-dependent model is correct, would not receive a forward spread of activation from the ambiguous word in this context (thus is similar to the backward associates in the present study). By mimicking the ambiguity literature in this way, the present study will be much more generalizable to this body of research.

The 64 primes which correspond to word targets (as opposed to nonword targets), were randomly ordered and recorded on one channel of a reel-to-reel stereo tape. Sentence forms of these primes were also recorded, in the same order, on a different tape. Two additional tapes were made by randomly inserting the primes corresponding to the nonword targets into this sequence, and recording the 128 total primes (both for the single-word and sentence forms). For all four tapes, brief 1000 Hz tones were placed on a separate channel, such that the tones coincided with the offset of each prime word. The point of offset of the primes was determined by running the tapes slowly over the head of a reel-to-reel tape recorder, and noting where the auditory signal corresponding to the prime terminated.

Design and Procedure

The design which was used, for each reponse task (naming and lexical decision), was a 8 X 2 X 2 X 2 X 2 mixed factorial, with two between- and three within-subjects variables. The two between-subject factors were list (corresponding to eight stimulus lists) and form of the prime (single-word and sentence), while the three within-subject factors correspondede to ISI (0 msec and 200 msec), direction of association (forward and backward), and relatedness (related and unrelated).

The primes associated with word targets were randomly paired with one of the four possible types of targets (forward-related, forward-unrelated, backward-related, backward-unrelated), with the restriction that an equal number of primes be assigned to each target type. Unrelated targets were created by randomly re-pairing targets and primes. This re-pairing was done separately for the forward and backward associates. Thus, even though the distinction between forward and backward associates is meaningless for unrelated pairs, this re-pairing allowed a related-unrelated comparison to be made on the same stimulus items. In addition, the delay between the prime and target was randomly assigned to prime-target pairings, with the restriction that, across all 64 primes, eight primes be associated with each of the eight ISI X Direction of Association X Relatedness target combinations. This entire randomization scheme resulted, then, in an initial target list. Seven additional lists were created from this first one by reassigning primes to a different ISI X Direction of Association X Relatedness combination, such that, across the eight lists, all primes were paired with all possible combinations of targets and delay. For nonword targets in the lexical task, a given prime appeared with the same nonword across all eight lists.

Subjects were run individually, and were seated in front of a Commodore PET microcomputer at a distance of approximately 60 cm. On each trial, they heard a prime (either a single-word or a sentence), which was presented to them through a pair of headphones. At the end of the prime word, a tone from the other channel of the recorder (which was not heard by subjects) was fed into a voice-activated relay, which was interfaced with the microcomputer. When the tone activated the relay, the computer presented the appropriate target either immediately or after a 200 msec delay, and started a millisecond timer. For the naming task, subjects were asked to name the target word out loud, as rapidly as possible. The sound of the subject's voice triggered a second voice-activated relay which, through the computer, stopped the millisecond timer, and cleared the computer screen. For the lexical decision task, subjects were asked to decide whether the target item was a word. They indicated their decision by pressing, either with the right or left index finger, one of two response buttons. For all subjects, the WORD response was assigned to the subject's preferred hand. As with the naming response, the lexical decision response stopped the timer and cleared the computer screen. For both tasks, there was approximately a 4 sec interval between a subject's response and the start of the next trial.

To insure that subjects were attending to the primes, a comprehension task was given to them immediately following the completion of a trial, for a randomly selected 25 per cent of the trials. For the single-word group, this task involved giving the subjects a word, over the headphones, and having them decide whether it was the prime word from the trial they had just completed. Subjects made their decision by pressing one of the buttons on the response box with either their right or left index finger (the YES response was always assigned to the subject's preferred hand). For the sentence group, the subjects were given a statement and were asked to decide whether it was true or false with respect to the sentence they heard on the last trial. As with the single-word group, subjects reponded by pressing one of two buttons on the response box, with the

TRUE response assigned to their preferred hand. Subjects in both groups were quite accurate at this task. The mean proportion of errors for the single-word group was .02 (with no subject having a higher error proportion than .12), while for the sentence group it was .04 (with no subject higher than .18).

In total, subjects in the naming task condition were given 64 trials, while subjects making a lexical decision had 128. For both groups, breaks were provided at the end of each block of 32 trials. In addition, all subjects were given 16 practice trials, half of which used a 0 msec ISI and half a 200 msec ISI. For the naming task, these 16 trials consisted of eight related and eight unrelated trials. For the lexical decision task, eight trials were nonword trials, four were related trials, and four were unrelated. For both tasks, the prime and target on related trials were associated in a forward direction (hence, during the practice trials, no subjects were exposed to any materials which were associated only in a backward direction).

## Results

For each subject, the mean response latency was computed for each ISI X Direction X Relatedness condition. For both the naming and lexical decision data, reaction times were excluded from the analysis if a) the response was longer than 2 sec, b) a mechanical failure occurred on the trial (the subject's response failed to activate the relay or the relay was activated by extraneous noise), or, c) the subject made an error (a mispronunciation in the naming task or an incorrect decision in the lexical decision task). For each response task (naming and lexical decision), an 8 (List) X 2 (Prime type) X 2 (ISI) X 2 (Direction) X 2 (Relatedness) mixed factorial analysis of variance was conducted on the mean latencies, with List and Prime serving as between-subject factors (see Appendices A and B for the summary tables for these two analyses). An additional and parallel analysis of variance was carried out, for each task, on subjects' error proportions. The means for response latencies and error proportions are given in Table 1. The following discussion of the results will focus primarily on the latency data, with error data reported when they serve to qualify the latency results.

Naming task

For the naming task, responses were faster at a 200 msec delay than at a 0 msec delay (462 versus 469 msec), $F(1,48) = 11.148$, $p<.01$, $MSe = 509.91$, forward targets were responded to more quickly than backward targets (460 versus 471 msec), $F(1,48) = 36.286$, $p<.001$, $MSe = 463.348$, and subjects were quicker to name related than unrelated targets (459 versus 472 msec), $F(1,48) = 43.510$, $p<.001$, $MSe = 506.173$.

Direction and Relatedness interacted, $F(1,48) = 14.374$,

Table 1
Mean Response Latencies (in Milliseconds) and Error Proportions (EPs) as a function of Prime, ISI, Direction, and Relatedness for both Naming and Lexical Decision.

| | 0 msec ISI | | | | 200 msec ISI | | | |
|---|---|---|---|---|---|---|---|---|
| | Forward | | Backward | | Forward | | Backward | |
| | Mean | EP | Mean | EP | Mean | EP | Mean | EP |
| NAMING | | | | | | | | |
| Single-word primes | | | | | | | | |
| Related | 459 | .03 | 464 | .05 | 449 | .01 | 465 | .03 |
| Unrelated | 480 | .03 | 486 | .05 | 467 | .03 | 472 | .05 |
| Priming | 21 | | 22 | | 18 | | 7 | |
| Sentence primes | | | | | | | | |
| Related | 448 | .02 | 476 | .04 | 446 | .02 | 466 | .01 |
| Unrelated | 467 | .03 | 471 | .03 | 463 | .04 | 471 | .05 |
| Priming | 19 | | -5 | | 17 | | 5 | |
| LEXICAL DECISION | | | | | | | | |
| Single-word primes | | | | | | | | |
| Related | 528 | .05 | 564 | .05 | 532 | .03 | 557 | .05 |
| Unrelated | 570 | .09 | 586 | .12 | 567 | .09 | 583 | .07 |
| Priming | 42 | | 22 | | 35 | | 26 | |
| Sentence primes | | | | | | | | |
| Related | 561 | .05 | 614 | .07 | 555 | .02 | 580 | .10 |
| Unrelated | 580 | .07 | 600 | .09 | 592 | .07 | 587 | .11 |
| Priming | 19 | | -14 | | 37 | | 7 | |

$p<.001$, $MSe = 293.629$, but this interaction was qualified by a significant Prime X Direction X Relatedness interaction, $F(1,48) = 4.407$, $p<.05$, $MSe = 293.629$. To examine this interaction, simple interaction effects were computed for the Direction X Relatedness interaction for each prime type. For single word primes, there was a significant effect of Direction, $F(1,48) = 6.92$, $p<.025$, and of Relatedness, $F(1,48) = 31.034$, $p<.001$. The Direction X Relatedness interaction, however, was not significant, $F(1,48)<1$, indicating that priming occurred for both forward and backward associates. For sentence primes, there was a significant effect of Direction, $F(1,48) = 24.368$, $p<.001$, and Relatedness, $F(1,48) = 9.547$, $p<.01$, but the Direction X Relatedness interaction was significant as well, $F(1,48) = 8.675$, $p<.01$. To investigate this simple interaction, further simple effects analyses were conducted for the Relatedness factor at each direction of association. These analyses revealed that priming occurred for forward associates, $F(1,48) = 18.211$, $p<.01$, but not for backward associates, $F(1,48)<1$.

In summary, the significant Prime X Direction X Relatedness interaction found with the naming latency data suggests that priming for forward associates occurs for both single-word and sentence contexts. Backward associates, on the other hand, show priming with single-word primes only. Since previous studies, which have used relatively long delay intervals, have failed to show priming for backward associates with a naming task (Seidenberg et al., 1984; the pilot study for the present research), an *a priori* comparison was made between the backward priming obtained at the 0 msec and the 200 msec ISIs for the single-word prime data (22 versus 7 msec, respectively). This difference was found to be marginally significant, $F(1,31) = 4.059$, $p=.053$, $MSe = 931.766$, suggesting that while backward priming occurred with single word primes, the effect decreased over time.

In addition to the above effects, the List factor was involved in several interactions. Before discussing these, it is worthwhile to recall that the List factor refers to the eight different stimulus lists which were created to counterbalance the stimulus items across subjects. The lists were constructed by first randomly assigning the 64 forward associate and backward associate pairs to the eight ISI X Direction X Relatedness conditions. This created a first stimulus list. Seven additional lists were generated by rotating the eight stimulus sets across conditions such that across the eight lists, each stimulus set appeared in each of the eight conditions.

Of the significant List interactions, the one of highest order (and which qualified all other List interactions) was the List X ISI X Direction X Relatedness four-way interaction, $F(7,48) = 3.832$, $p<.01$, $MSe = 423.480$.

Simple effects analyses were conducted for the ISI X Direction X Relatedness interaction for each list. This interaction reached significance for one list, $F(1,48) = 10.092$, $p<.025$. For that list, further simple effects tests were made for the Direction X Relatedness interaction at each delay interval. The Direction X Relatedness interaction was significant at the 200 msec ISI only, $F(1,48) = 14.547$, $p<.01$. Simple effects analyses revealed that this interaction resulted from a significant negative priming effect for forward associates (i.e. the mean latency for the related condition was 25 msec slower than for the unrelated condition), $F(1,48) = 5.903$, $p<.05$, and a significant positive priming effect for backward associates (i.e. the mean latency for the related condition was 30 msec faster than the unrelated condition), $F(1,48) = 8.787$, $p<.01$.

The negative priming effect found with forward associates appears to be attributable to a particularly difficult set of items which appeared in the related condition for that list. These items are both longer in length than any other set of items (a mean of 5.75 letters per word compared to 5.0 for the rest of the items) and much lower in mean frequency than the other items (72.75 occurrences per million per word versus 143.32 for the remaining items). Across lists, this set of items tended to have longer mean response latencies, regardless of condition. Thus, whenever this set of items appeared in a related condition, negative priming occurred, and whenever it appeared in an unrelated condition, larger than average positive priming was obtained (a mean of 46 msec).

In a like manner, the large positive priming found with backward associates is attributable to the characteristics of the set of items which appeared in the related condition of the list. In this case, the items are far easier than average: they are both shorter in length than any other set of backward associate items (4.4 letters per word compared to 5.3 for the rest) and have a higher mean frequency than any other set (224.875 occurrences per million per word versus 26.00 for the remaining items). Across lists, relatively short mean latencies resulted from these items regardless of condition, evidenced by the fact that large positive priming effects occurred whenever the items appeared in a related context, and negative priming occurred whenever the items were in an unrelated condition.

Thus, the ISI X Direction X Relatedness interaction found with the one list appears to be due to two extreme sets of stimuli which led to opposite effects for forward and backward associates in the 200 msec delay condition. While these extreme sets tended to exert an influence on other lists as well, it was only in the one list that they directly opposed each other and led to a large enough interaction effect to reach significance. Several points should be noted with respect to this phenomenon, however. First, the resulting effects are of no theoretical importance to the present study. Second, since across all lists, all stimulus sets appear in all conditions, there is no methodological concern with respect to these effects. Finally, the List factor never interacted with the Prime factor and, hence, in no way qualifies the obtained Prime X Direction X Relatedness interaction, the nature of which was summarized above.

In the error analysis for the naming task, it was found that forward associates had a lower proportion of errors than backward associates (.026 versus .041), $F(1,48) = 7.988$, $p<.01$, $MSe = .003$, related targets led to a lower error proportion than unrelateds (.025 versus .042) , $F(1,48) = 7.280$, $p<.01$, $MSe = .004$. Delay and Relatedness interacted, $F(1,48) = 7.280$, $p<.01$, $MSe = .004$. Simple effects analyses revealed that there was no difference in the proportion of errors between related targets and unrelated targets at a 0 msec ISI (.034 versus .035, respectively), $F(1,48)<1$, but at 200 msec, a significantly higher proportion of errors were made in the unrelated condition (.017 versus .049 for related and unrelated targets, respectively), $F(1,48) = 7.735$, $p<.01$. The primary importance of these error data is that they show no evidence of a speed-accuracy tradeoff, and hence do not qualify the latency results presented above.

*Lexical decision task*

For the lexical decision task, forward associates led to shorter response latencies than did backward associates (561 versus 584 msec), $F(1,48) = 34.235$, $p<.001$, $MSe = 1989.322$, related targets were responded to more quickly than unrelated targets (561 versus 583 msec), $F(1,48) = 28.975$, $p<.001$, $MSe = 2138.861$. However, these main effects were qualified by a significant Direction X Relatedness interaction, $F(1,48) = 6.610$, $p<.025$, $MSe = 2473.054$. Simple main effects were computed for the Relatedness factor for forward and backward associates. For forward associates, the 33 msec priming effect was significant, $F(1,48) = 14.352$, $p<.01$. The 11 msec priming effect for backward associates, however, was found to be nonsignificant, $F(1,48) = 1.482$, $p>.10$. Thus, the Direction X Relatedness interaction indicates that priming occurred for forward associates only, for both single-word and sentence primes.

The above finding is contrary to the results observed with the naming task, where it was concluded that backward priming did occur when single-word primes were used. The lack of a similar backward priming effect with the lexical decision task might, however, be somewhat misleading. Inspection of the data reveals that there is a large difference between the amount of backward priming obtained with single-word primes (24 msec) and sentence primes (-3 msec). The trend of the lexical decision data is, therefore, quite consistent with the naming task results. Both because of this consistency, and the fact that previous research has found that backward priming occurs with single-word primes when a lexical decision task is used (Koriat, 1981; Seidenberg et al.,1984; the pilot study of the present research), the Prime X Relatedness interaction was tested for the backward associate data alone. This interaction was found to be significant, $F(1,62) = 4.231$, $p<.05$, $MSe = 1452.610$. Simple effects analyses demonstrated that the 24 msec priming effect found with single-word primes was significant, $F(1,62) = 6.645, p<.05$, while the -3 msec effect found with sentence primes was not, $F(1,62)<1$. Thus, there is some indication that backward priming does occur with a lexical decision task, at least when single-word primes are used. However, there is no indication that this priming decreased from the 0 msec ISI to the 200 msec ISI (an effect which did occur with naming). In fact, the backward priming effect was 4 msec larger at 200 msec.

As with naming, there was a significant List X ISI X Direction X Relatedness interaction. Again, the effect appears to be due to differences among stimulus sets which, when rotated across conditions, led to different patterns of results across lists. Simple effects analyses were conducted which tested the ISI X Direction X Relatedness interaction for each list. The list for which this interaction was significant with the naming task also yielded a significant interaction with the lexical decision task, and for the same reasons---negative priming for forward associates and large positive priming for backward associates at a 200 msec delay. For the reasons presented earlier with respect to the list effects found with the naming task, the list effects found with the lexical decision task do not seem to qualify any of the other observed effects.

The error analysis for the lexical decision task indicated that forward associates led to a smaller proportion of errors than backward associates (.059 versus .082), $F(1,48) = 9.121$, $p<.01$, $MSe = .007$, and related targets led to fewer decision errors than unrelateds (.052 versus .088), $F(1,48) = 28.324$, $p<.001$, $MSe = .006$. Prime and Direction interacted, $F(1,48) = 4.983$, $p<.05$, $MSe = .007$. Simple effects analyses indicated that there was no significant difference in the error proportion between forward and backward associates for single-word primes (.065 versus .070, respectively), $F<1$, but for sentence primes the difference was marginally significant, with a smaller proportion of errors made with forward associates (.054 versus .093), $F(1,48) = 3.45$, $p<.10$. As with naming, the primary importance of the error data is that there is no evidence of a speed-accuracy trade-off, therefore the error data do not qualify the decision latency data presented above.

## Discussion

The primary concern of the present research was to identify conditions which give rise to backward priming. It was hoped that this information could be used both to determine whether backward priming occurs in the ambiguity literature, and to infer the locus of the backward priming effect.

Certainly the most noteworthy discovery from this study was the occurrence of backward priming with a naming task. This finding contradicts the claim that naming latencies are insensitive to backward relationships between the prime and target (Seidenberg et al., 1984). The critical difference between the current research and the study by Seidenberg et al. (1984) appears to be the length of the delay employed between the presentation of the prime and target. Seidenberg et al. used a 500 msec SOA (a relatively long delay), while in the current experiment the target followed the offset of the prime either immediately or after 200 msec. The present study found, with single-word primes, a large backward priming effect at the 0 msec ISI, but this effect decreased by 200 msec. This suggests that backward priming, at least with a naming task, is time-sensitive, occurring only with short delay intervals between the prime and target. The delay used by Seidenberg et al. might have been, therefore, too long for backward priming to occur.

In many respects, the lexical decision results mirror those found with naming. Priming was obtained for backward associates, but, like naming, only when single words served as primes. One fundamental difference between the lexical decision and the naming results, however, is that the backward effect with lexical decision showed no signs of decreasing across the 200 msec delay. This finding is consistent with previous research (Koriat, 1981; Seidenberg et al., 1984; the pilot study for the present study) which have found backward priming with a lexical decision task even at long delay intervals.

Backward priming and lexical ambiguity research

The present study was designed to mimic the ambiguity literature in order to determine if backward priming occurs in those situations which have been shown to lead to priming for both contextually appropriate and contextually inappropriate meanings of ambiguous words. If backward priming does occur in these situations, then it would be inappropriate to use exhaustive priming results as evidence in support of a context-independent model of lexical ambiguity processing (as has been done by Seidenberg et al., 1982; Swinney, 1979; and Tanenhaus et al., 1979). That is, priming for contextually inappropriate targets, rather than reflecting a forward spread of activation from the ambiguous words, could simply be the result of backward priming.

Despite the fact that the present study found backward priming in situations where it was thought not to occur (i.e., with a naming task), it found no evidence which would suggest that backward priming occurs in lexical ambiguity studies, at least not in those studies which have sought to distinguish between a context-independent and -dependent model of ambiguity processing. These ambiguity studies have generally used ambiguous words embedded in a sentence context, and, since the present study failed to find any evidence of backward priming with sentence primes, the results of these studies are not qualified by the findings of the present experiment. This is a particularly important point, since it has been suggested by Seidenberg et al. (1984) that the results from ambiguity studies which have used the lexical decision task might likely be tainted by backward priming effects. The present study suggests that such a problem may not exist, and thereby solidifies the credibility of a number of important studies (e.g., Kintsch & Mross, 1985; Simpson, 1981; Swinney, 1979).

The present results do suggest, however, that ambiguity studies which have used single-word primes might be subject to backward priming effects. However, a study by Simpson and Burgess (1985) appears to refute this suggestion. These researchers presented subjects with isolated ambiguous words as primes, and targets which were related either to the dominant or subordinate meaning of the ambiguous word.

Simpson and Burgess, using an all-visual presentation technique, a lexical decision task, and a wide-range of SOAs, found that at the shortest SOAs (e.g., 16 msec) priming occurred for targets related to the dominant meaning of the ambiguous word only. By a 300 msec SOA, targets related to both dominant and subordinate meanings were primed. At an SOA of 750 msec, once again only the dominant target showed priming. Simpson and Burgess argued that backward priming could not account for these findings since, if backward priming had occurred, it presumably would have resulted in equivalent amounts of priming for both targets across all delays. This seems to be a legitimate argument, but it leaves open the question of why backward priming apparently failed to occur in the Simpson and Burgess study, yet was found in the present study, as well as in studies by Seidenberg et al. (1984) and Koriat (1981). Unfortunately, this question has no obvious answers. It would be worthwhile, in an effort to resolve these conflicting data, to repeat the present experiment using a visual display of the prime and a sampling of SOAs similar to those used by Simpson and Burgess.

Overall, then, the present results appear not to qualify the conclusions which have been drawn in the ambiguity literature. The results do, however, have important implications regarding the locus of the backward priming effect. The remainder of the discussion is devoted to this topic.

The locus of the backward priming effect

Seidenberg et al. (1984) have argued that a backward association between the prime and target does not influence lexical access of the target. They reached this conclusion on the basis of evidence showing that backward priming occurred with a lexical decision task, but not naming. Since both tasks are sensitive to changes in speed of lexical access, the failure to find backward priming with a naming task suggested to the researchers that the locus of the effect was in post-access processing specific to the lexical decision task. If Seidenberg et al. are correct regarding the lack of sensitivity of lexical access processes to backward relationships, then, in the present study, naming latencies must also, for some reason, have been influenced by post-access processes. While researchers have generally regarded naming tasks as being influenced little by post-access processing (Seidenberg et al., 1984; West & Stanovich, 1982; but see Balota & Chumbley, 1985), it might be that, under extreme conditions, such processes could exert an effect. Stanovich and West (1983), for example, have demonstrated larger effects of context on naming latencies when the processing of the target is in some way slowed (e.g. by physically degrading the target or by using, as targets, long, infrequent words). One possible explanation for the enhanced context effects is that subjects, when presented with difficult or unusual targets to name, might set a more rigid criterion for responding (i.e., for deciding that the word that they retrieved is indeed the stimulus which was presented). Under such a circumstance, the discovery of a relationship between the prime and target may ease the decision process, allowing faster responses for related items (and, perhaps, inhibition for unrelated items if this relatedness-seeking strategy causes subjects momentarily to reject the initial retrieval of an item which is both unusual and inconsistent with the prime word; see Stanovich & West, 1983, for a discussion of inhibition effects in naming).

Two aspects of the present study are consistent with the view that backward priming with a naming task is a reflection of post-access processing. First, the backward associates used in this study are generally of lower frequency than the targets which have been used in previous backward priming research (e.g., Koriat, 1981; Seidenberg et al., 1984). These items, therefore, might have, for the reasons described above, invoked a relatedness-searching strategy in subjects. Second, the present study provides some limited evidence which suggests that larger backward priming effects are associated with subjects who have relatively long naming latencies, an effect which is consistent with a post-access view of backward priming if it is assumed that these slower subjects, on average, adopt the strictest criterion for responding. Specifically, it was found that, for the 0 msec delay condition (where a large backward priming effect was found with naming), the slowest subject on each list showed a much larger priming effect than the remainder of the subjects (37 versus 18 msec, respectively). However, somewhat inconsistent with the post-access view is the fact that even the fastest subjects demonstrated a sizeable effect (the mean backward priming effect for the three fastest subjects on each list were, from fastest to slowest, 19, 16, and 18 msec). Thus, while slower responses seemed to lead to a larger backward priming effect, it is not clear whether the speed of responding can completely account for the occurrence of backward priming. Of course, it may be that the relative difficulty of the backward associates forced all subjects to depend on a relatedness-checking strategy, thereby resulting in a backward priming effect for even the fastest subjects. Obviously, more research is needed to clarify the role that response speed plays in backward priming.

The fact that backward priming occurred with single-word primes, but not with sentences, can be explained by a post-access mechanism as well. To do so, however, requires making the assumption that subjects recognize different types of relationships depending on the type of processing with which the subjects are involved. With sentence primes, subjects must actively compute an abstract representation of the meaning of the sentence. When the target is presented, subjects might, as a result of this sentential processing, notice a relationship between that target and the meaning of the sentence as a whole, but not necessarily between the target and individual words within the sentence. Since the backward associates were unrelated to the meaning of the sentence in the present study, such a strategy would fail to facilitate responses to these targets. Hence, for both the lexical decision and naming tasks, backward priming would not be observed.

Despite the ability of a post-access explanation to account for backward priming with both lexical decision and naming tasks, the account has one potentially fatal flaw. By hypothesizing that the same mechanism underlies the backward priming effect for both tasks, the post-access view has no way of accounting for the one observed difference between lexical decision and naming: the tendency for the backward priming effect to decrease over time with naming but not lexical decision. Since there is no apparent reason why a delay should affect a post-access recognition of a relationship between the prime and target, it appears that the post-access explanation is unable to account fully for the observed naming results (although it does seem to describe adequately the lexical decision data).

An alternative explanation for the backward priming effect found with naming is that the effect reflects changes in the speed of lexical access of the target per se, not post-access processing. Kiger and Glass (1983) have suggested this possibility, and have argued that the effect is dependent upon an overlap in processing between the prime and target (i.e., the target is presented before processing of the prime has been completed). Kiger and Glass claim that such an overlap allows activation to spread from the prime to the target, and vice-versa, thereby facilitating recognition of both stimuli. In a similar manner, Glucksberg et al. (1986) have argued that when the prime and target overlap in processing, they become "psychologically simultaneous" (p. 326), thereby allowing the target to serve as a context for the prime, and vice-versa, facilitating both prime and target.

The results of the present experiment are consistent with this stimulus-overlap argument since a large backward priming effect was found with the naming task at a 0 msec ISI (when processing of the prime and target are likely to overlap), but the effect decreased when a 200 msec delay occurred between the stimuli (when, at the time of the presentation of the target, the processing of the prime would be nearly complete). In addition, the overlap hypothesis can explain the failure to observe backward priming with sentence primes. Numerous studies have demonstrated that words are recognized more quickly when they are embedded in a supportive context than when they are presented in isolation (although the exact cause of this effect has generated a great deal of debate, e.g., Fischler & Bloom, 1985; Forster, 1981; Stanovich & West, 1983). In the present study, then, the prime word might have been recognized much more quickly in the sentence than in the single-word condition. If so, this would reduce the extent of overlap between the prime and target and, as a result, decrease and/or eliminate the backward priming effect. Thus, the overlap hypothesis suggests that the elimination of the backward priming effect with sentence primes is not a result of sentence processing per se, but rather is a by-product of the facilitative effects of context on the processing of the prime. Notice that this argument suggests that backward priming could be found with sentence primes, if the sentences were semantically neutral (such as "they said it was the"), since, in these contexts, the prime would receive little or no facilitation.

Although a stimulus overlap view adequately explains the naming task results, the idea that there is a mutual spread of activation from target to prime, and vice-versa, is somewhat problematic for the stimuli used in the present study. That is, with unidirectional associates presented in a backward order (e.g., BABY-STORK), it is not clear how activation can spread from the prime to the target (since no such forward link exists between the stimuli). Any attempt to resolve this problem would require a rather precise specification of the structures underlying spreading activation. For example, it could be argued that the spread of activation from the target intersects that of the prime, and that this intersection is the focus of further processing, resulting in facilitation for both target and prime. Unfortunately, there is little direct evidence on which to base such an intersection model (although the concept of intersecting pathways has long played an important role in models of semantic memory, e.g., Collins & Quillian, 1969). Until more empirical evidence is accumulated with regard to the nature of spreading activation, the overlap view seemingly will remain theoretically vague, at least with respect to the results of the present experiment.

It is possible, however, to use the concept of stimulus overlap to account for backward priming, without insisting that, for backward associates, activation spreads from the prime to the target. Becker (1976) has demonstrated that lexical retrieval processes are resource-demanding, and that they interfere with a concurrent task (in his study, a tone recognition task). Since lexical priming is thought to speed lexical retrieval, then it may serve to reduce this interference. Applied to the present research, it might be that recognition of the prime demands limited resources, and that this interferes, in some way, with the naming of the target. If the target is presented prior to the recognition of the prime, then activation may (for backward associates) spread from the target to the prime, speed the prime's recognition, and reduce or eliminate this interference. As a result, faster responses to the target would be obtained. It is important to note that this argument is predicated on the assumption that activation can begin to spread from the target before the target itself has been fully recognized. This is a credible assumption since it has been demonstrated that activation can spread from an item even when the duration of presentation of the item is far below that required for its identification (Fischler & Goodman, 1978; McCauley, Parmalee, Sperber, & Carr, 1980). Thus, according to this interference view, backward priming is merely a reflection of the facilitation in processing of the prime which arises as a result of the spread of activation from the target to the prime. Quicker responses to the target are, according to this view, simply a by-product of the facilitation for the prime.

This interference view, since it emphasizes the importance of the overlap in processing between the prime and target, makes the same predictions, in terms of the situations under which backward priming should occur, as the stimulus-overlap explanation given by Kiger and Glass (1983) and Glucksberg et al. (1986). The two explanations do, however, differ in terms of whether the reduction in backward priming at the 200 msec ISI is a reflection of an increase in response latencies for related trials or a decrease in latencies for unrelated trials. Consider, for example, the Kiger and Glass (1983) view. This position argues that at a 0 msec ISI there is a maximum amount of overlap between the prime and target which leads to heightened activation for the related target. By 200 msec, however, there is little overlap, and little facilitation for the related target occurs. Hence, this view argues that naming latencies for related items should be longer at a 200 msec than a 0 msec ISI. Latencies for unrelated items, however, should not vary across ISI since they do not receive any facilitation in processing, regardless of the extent of overlap. The interference view, on the other hand, predicts that, at a 0 msec ISI, there should, in general, be a great deal of interference in responding to the targets. Related items, however, should greatly reduce this interference (thereby resulting in a large backward priming effect at a 0 msec ISI). At 200 msec, there should be little interference for _any_ items since the processing of the prime has, by that time, been nearly completed. Overall, then, the latency for responding to related targets should be similar at both ISIs (since little interference occurs for these items at either delay). Unrelated targets, on the other hand, should be responded to much more quickly at the 200 than the 0 msec ISI.

The data support the interference reduction hypothesis since there is little difference in response latencies for related items at each ISI (464 versus 465 msec for the 0 msec and 200 msec ISIs, respectively), but there is a difference for unrelateds (486 versus 472 msec, respectively). Thus, the 15 msec decrease in backward priming from the 0 msec to the 200 msec ISI is almost entirely attributable to the 14 msec decrease in response latency for unrelated targets. It is difficult to see how any explanation, other than the interference view, could account for this finding.

Summary

The phenomemon of backward priming has been the subject of much recent discussion. Unfortunately, conclusions which have been drawn with respect to the nature of this effect have been based on the findings of only a few studies, which themselves have been limited in terms of the conditions under which backward priming has been tested. The present study hopefully provides a more general foundation upon which future arguments can be based.

One important finding of the present study was that backward priming occurred with a naming task. Because of this finding, it seems that backward priming can no longer be seen simply as an anomaly of the lexical decision process (Seidenberg et al., 1984). Unfortunately, it is difficult, from the present data, to make any definitive statements regarding the locus of this naming-based backward priming effect. One possibility that was discussed, however, is that naming, like lexical decision, can be influenced by post-access processes, given appropriate conditions. The present results suggest, however, that this may not be an adequate explanation. The differential sensitivity of lexical decision and naming latencies to the time delay between the prime and target, suggests that a different mechanism underlies the backward priming effect in each task. While the lack of sensitivity of the lexical decision task to a time delay is quite consistent with a post-access view, the decrease, over time, in backward priming with naming is not. Thus, it appears necessary to find an alternative explanation for naming-based backward priming. Two such explanations were considered, both of which focused on the possibility that an overlap in processing may have occurred between the prime and target at the short delay interval (i.e., the 0 msec ISI). One explanation suggests that such an overlap would allow a mutual spread of activation to occur between the prime and target, thereby facilitating recognition of both stimuli (Glucksberg et al., 1986; Kiger & Glass, 1983). The other explanation suggests that an overlap may create interference in responding to the target, and a backward spread of activation from the target to the prime may serve to reduce this interference. Both of these explanations are admittedly speculative, and ultimately deciding which is correct, if either, will require additional research. In terms of the present results, however, it seems that the interference view is best able to account for the entire constellation of results.

Finally, since the present study attempted to mimic the conditions found in the ambiguity literature, generalizations to this body of research are easier to make from the results of the present study than from previous studies of backward priming. Of particular importance in this regard, is the finding that backward priming failed to occur with sentence primes. This implies that conclusions from ambiguity studies which have used sentences as stimuli are free from a backward priming confound. Because of the importance of this claim, it seems critical to test for backward priming under a wider variety of sentence contexts (e.g., by varying the constraint of the sentence). It is only through such an expansion of the conditions under which the backward priming effect is investigated, that a more complete understanding of its nature can be achieved.

References

Balota, D. A., & Chumbley, J. I. (1985). The locus of word-frequency effects in the pronunciation task: Lexical access and/or production? Journal of Memory and Language, 24, 89-106.

Becker, C. A. (1976). Allocation of attention during visual word recognition. Journal of Experimental Psychology: Human Perception & Performance, 2, 556-566.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. Psychological Review, 82, 407-428.

Collins, A. M., & Quillian, M. (1969). Retrieval time from semantic memory. Journal of Verbal Learning and Verbal Behavior, 8, 240-248.

Fischler, I. S., & Bloom, P. A. (1985). Effects of constraint and validity of sentence contexts on lexical decisions. Memory & Cognition, 13, 128-139.

Fischler, I. S., & Goodman, G. O. (1978). Latency of associative activation in memory. Journal of Experimental Psychlogy: Human Perception and Performance, 4, 455-470.

Forster, K. I. (1979). Levels of processing and the structure of the language processor. In W. E. Cooper & E. Walker (Eds.), Sentence processing: Psycholinguistic studies presented to Merrill Garrett. Hillsdale, N.J.: Erlbaum, 27-85.

Forster, K. I. (1981). Priming and the effects of sentence and lexical contexts on naming time: Evidence for autonomous lexical processing. Quarterly Journal of Experimental Psychology, 33A, 465-495.

Forster, K. I., & Bednall, E. S. (1976). Terminating and exhaustive search in lexical access. Memory & Cognition, 4, 53-61.

Foss, D. J. (1970). Some effects of ambiguity upon sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 9, 699-706.

Glucksberg, S., Kreuz, R. J., & Rho, S. (1986). Context can constrain lexical access: Implications for models of language comprehension. Journal of Experimental Psychology: Learning, Memory, and Cognition, 12, 323-335.

Kiger, J. I., & Glass, A. L. (1983). The facilitation of lexical decisions by a prime occurring after the target. Memory & Cognition, 11, 356-365.

Kintsch, W., & Mross, E. F. (1985). Context effects in word identification. Journal of Memory and Language, 24, 336-349.

Koriat, A. (1981). Semantic facilitation in lexical decision as a function of prime-target association. Memory & Cognition, 9, 587-598.

Kucera, H., & Francis, W. (1967). Computational analysis of present-day American English. Providence, R.I.: Brown University Press.

Lupker, S. J. (1984). Semantic priming without association: A second look. Journal of Verbal Learning and Verbal Behavior, 23, 709-733.

Marshall, G. R., & Cofer, C. N. (1970). Single-word free association norms for 328 responses from the Connecticut cultural norms for verbal items in categories. In L. Postman & G. Keppel (Eds.), Norms of word association. New York: Academic Press.

Masson, M. E. J. (1984). Priming word identification with rapidly presented sentences. Paper presented at the annual meeting of the Psychonomic Society, San Antonio, Texas.

McCauley, C., Parmalee, C. M., Sperber, R. D., & Carr, T. H. (1980). Early extraction of meaning from pictures and its relation to conscious identification. Journal of Experimental Psychology: Human Perception and Performance, 6, 265-276.

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology, 90, 227-234.

Onifer, W., & Swinney, D. A. (1981). Accessing lexical ambiguities during sentence comprehension: Effects of frequency of meaning and contextual bias. *Memory & Cognition*, *9*, 225-236.

Palermo, D. S., & Jenkins, J. J. (1964). *Word association norms*. Minneapolis: University of Minnesota Press.

Postman, L., & Keppel, G. (1970). *Norms of word association*. New York: Academic Press.

Sabol, M. A.,& DeRosa, D. V. (1976). Semantic encoding of isolated words. *Journal of Experimental Psychology: Human Leaarning and Memory*, *2*, 58-68.

Schvaneveldt, R. W., Meyer, D. E., & Becker, C. A. (1976). Lexical ambiguity, semantic context, and visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, *2*, 243-256.

Seidenberg, M. S., & Tanenhaus, M. K. (in press). Modularity and lexical access. In I. Copnik (Ed.), *Papers from the McGill University Cognitive Science Workshops*.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. M., & Bienkowski, M. (1982). Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology*, *14*, 489-537.

Seidenberg, M. S., Waters, G. S., Sanders, M., & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. Memory & Cognition, 12, 315-328.

Shapiro, S. I., & Palermo, D. S. (1968). An atlas of normative free association data. Psychonomic Monograph Supplements, 2(No. 28), 219-250.

Simpson, G. B. (1981). Meaning dominance and semantic context in the processing of lexical ambiguity. Journal of Verbal Learning and Verbal Behavior, 20, 120-136.

Simpson, G. B. (1984). Lexical ambiguity and its role in models of word recognition. Psychological Bulletin, 96, 316-340.

Simpson, G. B., & Burgess, C. (1985). Activation and selection processes in the recognition of ambiguous words. Journal of Experimental Psychology: Human Perception and Performance, 11, 28-39.

Simpson, G. B., Peterson, R. R., Casteel, M. A., & Burgess, C. (1985). Lexical and sentence context effects in word recognition. Paper presented at the annual meeting of the Psychonomic Society, Boston, Massachusetts.

Stanovich, K. E., & West, R. F. (1983). On priming by a sentence context. Journal of Experimental Psychology: General, 112, 1-36.

Swinney, D. A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. Journal of Verbal Learning and Verbal Behavior, 18, 645-659.

Tanenhaus, M. K., Leiman, J. M., & Seidenberg, M. S. (1979). Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. Journal of Verbal Learning and Verbal Behavior, 18, 427-440.

West, R. F., & Stanovich, K. E. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 385-399.

West, R. F., & Stanovich, K. E. (1986). Robust effects of syntactic structure on visual word processing. Memory & Cognition, 14, 104-112.

Appendix A

ANOVA Summary Table (for naming latencies)

| Source | SS | DF | MS | F | p | $\omega^2$ |
|---|---|---|---|---|---|---|
| Prime | 2655.383 | 1 | 2655.383 | .157 | .693 | |
| List | 223635.648 | 7 | 31947.950 | 1.894 | .091 | |
| PrimeXList | 234899.398 | 7 | 33557.057 | 1.990 | .076 | |
| Within Cells | 809543.563 | 48 | 16865.491 | | | |
| Del | 5684.445 | 1 | 5684.445 | 11.148 | .002 | .0025 |
| PrimeXDel | 815.070 | 1 | 815.070 | 1.598 | .212 | |
| ListXDel | 39403.648 | 7 | 5629.093 | 11.039 | .000 | .0172 |
| PrimeXListXDel | 1048.648 | 7 | 149.807 | .294 | .953 | |
| Within Cells | 24475.688 | 48 | 509.910 | | | |
| Dir | 16813.195 | 1 | 16813.195 | 36.286 | .000 | .0078 |
| PrimeXDir | 1561.008 | 1 | 1561.008 | 3.369 | .073 | |
| ListXDir | 9984.586 | 7 | 1426.369 | 3.078 | .009 | .0032 |
| PrimeXListXDir | 6460.523 | 7 | 922.932 | 1.992 | .076 | |
| Within Cells | 22240.687 | 48 | 463.348 | | | |
| Rel | 22023.758 | 1 | 22023.758 | 43.510 | .000 | .0103 |
| PrimeXRel | 1807.508 | 1 | 1807.508 | 3.571 | .065 | |
| ListXRel | 5032.898 | 7 | 718.985 | 1.420 | .219 | |
| PrimeXListXRel | 3227.523 | 7 | 461.075 | .911 | .506 | |
| Within Cells | 24296.313 | 48 | 506.173 | | | |
| DelXDir | 31.008 | 1 | 31.008 | .067 | .797 | |
| PrimeXDelXDir | 409.695 | 1 | 409.695 | .886 | .351 | |
| ListXDelXDir | 6105.086 | 7 | 872.155 | 1.886 | .093 | |
| PrimeXListX DelXDir | 2961.148 | 7 | 423.021 | .915 | .503 | |
| Within Cells | 22200.062 | 48 | 462.501 | | | |
| DelXRel | 212.695 | 1 | 212.695 | .428 | .516 | |
| PrimeXDelXRel | 1194.383 | 1 | 1194.383 | 2.405 | .127 | |
| ListXDelXRel | 12527.023 | 7 | 1789.575 | 3.604 | .003 | .0043 |
| PrimeXListX DelXRel | 1675.461 | 7 | 239.352 | .482 | .843 | |
| Within Cells | 23835.438 | 48 | 496.572 | | | |

ANOVA Summary Table (for naming latencies, continued)

| Source | SS | DF | MS | F | p | $\omega^2$ |
|---|---|---|---|---|---|---|
| DirXRel | 4220.508 | 1 | 4220.508 | 14.374 | .000 | .0019 |
| PrimeXDirXRel | 1294.133 | 1 | 1294.133 | 4.407 | .041 | .0005 |
| ListXDirXRel | 16942.273 | 7 | 2420.325 | 8.243 | .000 | .0071 |
| PrimeXListX DirXRel | 2103.398 | 7 | 300.485 | 1.023 | .427 | |
| Within Cells | 14094.187 | 48 | 293.629 | | | |
| DelXDirXRel | 3.445 | 1 | 3.445 | .008 | .929 | |
| PrimeXDelX DirXRel | 1294.133 | 1 | 1294.133 | 3.056 | .087 | |
| ListXDelX DirXRel | 11360.273 | 7 | 1622.896 | 3.832 | .002 | .0040 |
| PrimeXListX DelXDirXRel | 1590.586 | 7 | 227.227 | .537 | | |
| Within Cells | 20327.063 | 48 | 423.480 | | | |

# Appendix B

ANOVA Summary Table (for lexical decision latencies)

| Source | SS | DF | MS | F | p | $\omega^2$ |
|---|---|---|---|---|---|---|
| Prime | 65589.893 | 1 | 65589.893 | 1.719 | .196 | |
| List | 441052.342 | 7 | 63007.477 | 1.651 | .145 | |
| PrimeXList | 527017.748 | 7 | 75288.250 | 1.973 | .073 | |
| Within Cells | 1831740.219 | 48 | 38161.255 | | | |
| Del | 4906.689 | 1 | 4906.689 | 2.558 | .116 | |
| PrimeXDel | 1988.439 | 1 | 1988.439 | 1.037 | .314 | |
| ListXDel | 126439.764 | 7 | 18062.823 | 9.418 | .000 | .0176 |
| PrimeXListXDel | 18386.514 | 7 | 2626.645 | 1.369 | .240 | |
| Within Cells | 92062.219 | 48 | 1917.963 | | | |
| Dir | 68103.564 | 1 | 68103.564 | 34.235 | .000 | .0103 |
| PrimeXDir | .439 | 1 | .439 | .000 | .988 | |
| ListXDir | 29441.264 | 7 | 4205.895 | 2.114 | .060 | |
| PrimeXListXDir | 25510.389 | 7 | 3644.341 | 1.832 | .103 | |
| Within Cells | 95487.469 | 48 | 1989.322 | | | |
| Rel | 61974.002 | 1 | 61974.002 | 28.975 | .000 | .0093 |
| PrimeXRel | 7934.549 | 1 | 7934.549 | 3.710 | .060 | |
| ListXRel | 22690.576 | 7 | 3241.511 | 1.516 | .187 | |
| PrimeXListXRel | 24641.654 | 7 | 3520.236 | 1.646 | .147 | |
| Within Cells | 102665.344 | 48 | 2138.861 | | | |
| DelXDir | 7867.283 | 1 | 7867.283 | 3.865 | .055 | |
| PrimeXDelXDir | 3692.627 | 1 | 3692.627 | 1.814 | .184 | |
| ListXDelXDir | 48703.482 | 7 | 6957.640 | 3.418 | .005 | .0054 |
| PrimeXListX DelXDir | 13210.764 | 7 | 1887.252 | .927 | .494 | |
| Within Cells | 97706.469 | 48 | 2035.551 | | | |
| DelXRel | 2614.549 | 1 | 2614.549 | 1.475 | .230 | |
| PrimeXDelXRel | 3491.346 | 1 | 3491.346 | 1.970 | .167 | |
| ListXDelXRel | 82869.217 | 7 | 11838.460 | 6.681 | .000 | .0110 |
| PrimeXListX DelXRel | 16970.420 | 7 | 2424.346 | 1.368 | .240 | |
| Within Cells | 85055.094 | 48 | 1771.981 | | | |

ANOVA Summary Table (for lexical decision latencies, cont.)

| Source | SS | DF | MS | F | p | $\omega^2$ |
|---|---|---|---|---|---|---|
| DirXRel | 16346.580 | 1 | 16346.580 | 6.610 | .013 | .0022 |
| PrimeXDirXRel | 2454.377 | 1 | 2454.377 | .992 | .324 | |
| ListXDirXRel | 40057.686 | 7 | 5722.527 | 2.314 | .041 | .0035 |
| PrimeXListX DirXRel | 19919.889 | 7 | 2845.698 | 1.151 | .348 | |
| Within Cells | 118706.594 | 48 | 2473.054 | | | |
| DelXDirXRel | 383.299 | 1 | 383.299 | .227 | .636 | |
| PrimeXDelX DirXRel | 91.971 | 1 | 91.971 | .054 | .817 | |
| ListXDelX DirXRel | 50259.404 | 7 | 7179.915 | 4.244 | .001 | .0060 |
| PrimeXListX DelXDirXRel | 9107.107 | 7 | 1301.015 | .769 | .616 | |
| Within Cells | 81214.844 | 48 | 1691.976 | | | |

# Appendix C

## STIMULUS ITEMS

The stimuli listed below are in the same order as they were presented to subjects. Items with an asterisk represent nonword trials used with the lexical decision task. The underlined word in each sentence is the prime. The words which follow the sentences are the targets. For word trials, the first target pair represents <u>forward</u> associates (related and unrelated, respectively), while the final pair is composed of <u>backward</u> associates. The questions listed were the statements given to subjects in the sentence condition, who responded whether the statement was true or false. In the word prime condition, subjects were, at the same points, asked "Was the word" followed by either the prime from the last trial or a distractor word. Subjects made a yes/no response to this question.

1. They believe that it was a short in a wire which caused the house to start on <u>fire</u>. FLAME-DARK CAMP-TERMITE

2. It seems that, in the Middle East, there is a continuous series of <u>wars</u>. FIGHTING-UP STAR-CHECK

*3. He wasn't sure which flavor of life-savers to buy, but he finally decided on <u>cherry</u>. OANS

4. After running the marathon, the athlete desperately needed <u>water</u>. DRINK-ARMS DUCK-GARLIC

*5. The man went to see the opera which was being held in the large concert <u>hall</u>. FLONER

*6. He had just gotten laid off at work so he knew that he wasn't going to be able to pay his <u>rent</u>. DEAK

<u>QUESTION</u>: For the time being, he did not have a job.

*7. His shirt felt uncomfortable because the launderer had used too much <u>starch</u>. THEEK

8. The man always took his lunch to work in a brown paper <u>bag</u>. SACK-PAIN SLEEPING-TOMATO

9. The bank teller wasn't sure what the robber looked like because he wore a <u>mask</u>. DISGUISE-BOTTOM CATCHER-BELLY

*10. For a birthday present, the man gave his wife a necklace made out of solid <u>gold</u>. BLAGE

<u>QUESTION</u>: He gave her an anniversary present.

*11. At the restaurant, the woman didn't feel like having steak so instead she ordered the <u>fish</u>. GROG

12. She decided not to buy the garment because it was missing a <u>button</u>. COAT-HANG BELLY-SWIM

<u>QUESTION</u>: She was perfectly satisfied with the garment.

13. The economy of the northwestern part of the United States is greatly enhanced when there is a large demand for <u>wood</u>. TREE-COLOR TERMITE-LAMP

14. The meteor crashed into the planet and created a large <u>hole</u>. GROUND-VEHICLE DOUGHNUT-TOWEL

15. The boss tried to get some of his employees to volunteer to work all weekend, but he was unable to get a single <u>person</u>. INDIVIDUAL-SACK FAMOUS-STOMACH

*16. Mountain climbers take many safety precautions to ensure that they don't <u>fall</u>. WHASE

17. The man was building a dog house but he wasn't able to finish it because he needed one more <u>board</u>. LUMBER-GRASS BULLETIN-HARVEST

<u>QUESTION</u>: The man was building a bird house.

*18. The senior was anxious for the end of the school year when he would be <u>graduating</u>. CHURT

<u>QUESTION</u>: The student was soon going to graduate.

*19. He is very good in English but he has always had trouble with <u>math</u>. NEGULAR

*20. When the woman got into an argument, she always made sure that she got in the last <u>word</u>. BENNIS

21. It had been months since the last rain, and the ground had become hard and <u>dry</u>. ARID-FOUND TOWEL-MAZE

22. The cowboy had his name engraved on his leather <u>belt</u>. TROUSERS-DOOR SEAT-KINGDOM

*23. The peacock is known for its dazzling display of feathers. CIN

24. When the man desperately needed money, many of his friends gladly came to his aid. HELP-SHOPPING FIRST-FLEA

25. The wallpaper fell down because when the man put it up he didn't use enough paste. GLUE-INDIVIDUAL TOMATO-FAMOUS

QUESTION: The wallpaper didn't stick very well.

*26. The hostess asked the woman if she wanted coffee, and she replied that she wouldn't mind having half a cup. DRIMER

*27. The man originally had signed the contract with a pencil, but it was returned to him with a note requesting him to sign it in ink. TWARL

*28. The boy was caught cheating on an exam, and, while he wasn't expelled, he was given a very stern warning. GORB

QUESTION: The boy was kicked out of school.

29. They were going to a fancy restaurant so the man's wife demanded that he put on a nice suit. DRESS-COLD SWIM-CANYON

*30. The active volcano erupted, spewing into the air great clouds of ash. SIB

31. The man bought a new car but his wife didn't like the fact that it was bright yellow. COLOR-CEILING CANARY-CAMP

QUESTION: The man's wife didn't like his choice.

*32. He didn't like the hamburger because it didn't have enough meat. CALINET

*33. The boy liked to daydream about being a pirate and sailing around the world discovering treasure. NUSHES

34. The dictator demanded that he have absolute control. RULE-READ BIRTH-SIT

*35. The woman bought a beautiful candlestick holder which was made entirely of brass. PORAL

*36. The little girl's parents took her to the zoo for the first time, and she was particularly excited by the <u>elephants</u>. SHIPE

<u>QUESTION</u>: The girl was totally bored by the zoo.

37. The presence of the stranger upset the <u>baby</u>. CRY-SKY STORK-DENIM

<u>QUESTION</u>: The baby was happy to see the strange person.

38. When it was time to execute the prisoner, the officials couldn't find a suitable <u>rope</u>. HANG-DRESS JUMP-STOVE

39. Although she was generally pleased with her appearance, the woman didn't think that she had very nice <u>legs</u>. ARMS-DRINK CRAB-DUCK

*40. When the distinguished admiral died, plans were made to bury him at <u>sea</u>. GART

*41. You could tell the professor was extremely sloppy because he always had piles of papers scattered all over his <u>desk</u>. FOOG

<u>QUESTION</u>: The professor tended to be a slob.

42. It was supposed to be a very cold night, so the woman got out an extra <u>blanket</u>. BEDSPREAD-BRUSH SECURITY-BRICK

*43. The anthropologist was excited when he found the remains of an ancient village, along with a large number of human <u>bones</u>. THISKEY

*44. He wasn't very hungry for lunch so he just got himself an <u>apple</u>. BITTLE

*45. The all-american basketball player was the hero of the championship <u>game</u>. MORTH

46. The pessimist believed that, in life, we rarely get the things we <u>seek</u>. LOOK-FROSTING HIDE-BARN

47. The policeman gave the man a ticket for failing to come to a complete <u>stop</u>. SIGN-LUMBER BUS-CHEESE

*48. For their first date, the boy decided to take the girl to a dance. HARREL

QUESTION: The boy and the girl had been going together a long time.

49. The man didn't like his new shirt because it had too many stripes. LINES-WENT ZEBRA-MEN'S

QUESTION: The man's new shirt was one solid color.

*50. Nobody drank the lemonade because it was too sour. DORT

51. It was time to milk the cows, so the farmer went to get a bucket. PAIL-FABRIC ICE-CLOAK

QUESTION: The cows were ready to be milked.

52. She had been looking all day for her keys and she finally concluded that they were forever lost. FOUND-KNIFE MAZE-DOUGHNUT

53. The woman's son received an excellent report card, so as a reward she made him a delicious cake. FROSTING-TIE CHEESE-PUPPET

*54. The woman wanted to start a garden so she went out and bought a generous supply of seeds. INDER

*55. The family was very religious and they always made sure to attend church. FILK

56. The woman was out of groceries so she decided to go to the market. SHOPPING-SCARED FLEA-FIRST

QUESTION: The woman was going to buy something to eat.

57. She had broken her arm and, afterwards, she had trouble sleeping at night because lying on the arm made it ache. PAIN-WHITE STOMACH-MIRROR

58. The two boys had always been best friends and they were greatly saddened when they found out that the family of one of the boy's was going to move away. FAR-SOFT THROW-PIN

*59. We couldn't use our fireplace because some birds had built a nest in our chimney. TRIEF

60. The man loved just to sit around and listen to music. SONG-ODOR SHEET-BARE

*61. Every morning the class recited the "Pledge of Allegiance" while facing the American flag. PURDLE

*62. The horse stepped on a piece of broken glass and badly injured its hoof. BOT

63. The ambitious executive swore that someday he would make it to the top. BOTTOM-DISGUISE ROOF-WASHING

*64. The man's tires were low on air so they always squealed whenever he went around a sharp curve. SANDAY

QUESTION: The man needed to fill up his tires.

65. The chair was old and it desperately needed a new cushion. SOFT-FAR PIN-BEET

QUESTION: The chair was brand new.

*66. The man had been sick for a long time so he went to a doctor and found out that he had a disease which was potentially fatal. CURPED

67. The artist earned little money, but he didn't really care because he felt totally satisfied whenever he got a chance to paint. BRUSH-FLAME SPRAY-MOSQUITO

68. The murderer attacked his victim with a dagger. KNIFE-BLACK CLOAK-EYE

*69. An oil tanker sank and caused a huge oil spill in the middle of the ocean. CARK

QUESTION: The oil tanker polluted the ocean.

70. The president of the construction company was excited when his company got the contract to build the world's largest dam. RIVER-TROUSERS BEAVER-SLING

*71. He always ordered his martinis extra dry because he liked them to be very bitter. DIND

*72. Her new sweater shrank in the dryer because it was made entirely of wool. DRINY

*73. The woman was late for work so she knew that she had better run. MECTURE

74. The prisoner had served out his term and was finally granted <u>liberty</u>. FREEDOM-SHOE STATUE-CRAB

<u>QUESTION</u>: The prisoner was freed.

*75. It was only November, but the boy was already beginning to make a list of the things he wanted for <u>Christmas</u>. CREAN

76. The woman was going to buy a house out by the stockyards but she decided that she just couldn't tolerate the <u>smell</u>. ODOR-SONG GARLIC-STORK

77. As the man left the theater, after watching an afternoon movie, he was nearly blinded by the <u>light</u>. DARK-TEETH LAMP-SPRAY

<u>QUESTION</u>: The man saw the movie at night.

78. The boy wanted a pet so he went to the park and tried to capture a <u>pigeon</u>. BIRD-SIGN STOOL-HIDE

79. There was a party going on in the apartment below his, and, since he didn't have anything better to do, the man decided to go <u>down</u>. UP-NECK SIT-BIRTH

*80. The man couldn't sleep so he decided to get up and make himself a <u>sandwich</u>. REW

81. The woman's favorite color has always been a dark shade of <u>red</u>. WHITE-PICTURE BEET-THROW

82. The country was greatly saddened when its leader was ruthlessly <u>shot</u>. RIFLE-BREAD SLING-ZEBRA

*83. The woman has been married for seven years now, and she feels that her marriage has lost much of its <u>romance</u>. REFEREN

*84. The owner of the tavern always had a rock band play there on weekends because he knew that by doing so he would always be able to fill up the <u>joint</u>. BANTERY

85. The woman loved to curl up in bed with a good <u>book</u>. READ-FIGHTING CHECK-CHIP

*86. The opera singer was known to have an exceptionally beautiful <u>voice</u>. LUN

*87. You could tell that Joe was winning the poker game because his chips formed the largest stack. CORGET

QUESTION: Joe was losing badly.

*88. The parents were ecstatic when their 10 month son old took his first step. SCROW

89. The woman got a big pay raise so she decided to go out and buy some new clothes. WEAR-SHALLOW WASHING-ROOF

QUESTION: The woman was now making more money.

*90. The man hated the fact that his face had so many freckles. SWINT

QUESTION: The man liked his face.

91. The man didn't know how to swim so he stayed away from the end of the pool that was deep. SHALLOW-COAT CANYON-CATCHER

92. The postal clerk warned the man that before he mailed his package he should secure it tightly with plenty of string. TIE-LOOK PUPPET-STOOL

*93. The woman was going to repair the blouse, but she couldn't find a needle. VOSE

QUESTION: The blouse needed to be repaired.

94. Although the boss asked not to be disturbed during his meeting, his secretary nonetheless came barging into the room. DOOR-RIVER MEN'S-BEAVER

*95. The mother was very disappointed when she found out that her son had lied. BLING

*96. The baseball game was in extra innings and it seemed like it would never end, when all of a sudden Babe Ruth hit a grand slam. HILVER

*97. The woman wanted to relax so she decided to take a nice warm bath. SPEET

QUESTION: The woman needed to relax.

98. The tailor made the garment out of the finest available cloth. FABRIC-PAIL TABLE-DUMP

QUESTION: The tailor used very cheap material.

*99. She worked for an advertising agency and was quite successful because she could come up with ideas which were truly <u>innovative</u>. TRAN

100. Because they never watered it, nor fertilized it, the Smiths had a horrible looking <u>yard</u>. GRASS-PLANET BARN-BUS

101. The newly-married couple received many wedding gifts including three different sets of <u>dishes</u>. PLATES-RIFLE DIRTY-SEAT

*102. The terrorist who hijacked the plane threatened that he had a <u>bomb</u>. HAIN

103. It was a clear day and as you looked up all you could see was a vast stretch of <u>blue</u>. SKY-FREEDOM DENIM-STATUE

104. You could tell that the couple was in love because during the entire movie she had her head on his <u>shoulder</u>. NECK-HELP CHIP-STAGE

<u>QUESTION</u>: The couple had an argument.

*105. When the man wrecked his car he desperately wished that he had taken out <u>insurance</u>. BOUNTAIN

*106. The burglar got into the house through an open <u>window</u>. BLAT

*107. The boy wanted to continue playing the video game but he was out of <u>quarters</u>. WALON

<u>QUESTION</u>: The boy was out of money.

*108. The man came to a fork in the road and he wasn't sure which way to <u>turn</u>. OLEN

109. The man had a wonderful meal at the restaurant, although he did get upset when the waitress forgot to bring him some <u>butter</u>. BREAD-LINES PEANUT-DIRTY

*110. The boy slipped and fell down the stairs but remarkably he wasn't badly <u>hurt</u>. FLOST

111. The sun was setting and it caused the large tree to cast a long <u>shadow</u>. BLACK-ARID EYE-ICE

112. The man got a new set of dentures and for several weeks they hurt any time he took a bite. TEETH-TREE MOSQUITO-SECURITY

*113. At the carnival, the girl begged her father for a balloon. BAMON

QUESTION: The girl wanted ice cream.

114. The man wanted to be able to get around easily in the snow so he went out and bought himself a new truck. VEHICLE-GROUND DUMP-TABLE

115. The victim tried to describe her assailant to the policeman but the officer just couldn't, from her description, form a very clear image. PICTURE-GLUE MIRROR-SLEEPING

*116. The man knew that he would go bankrupt if his business went through another year of losing money. DEMORY

*117. The prosecutor knew that it would be a quick trial because it was an open and shut case. DARROT

118. The small boy was home alone one night, and every little sound that he heard gave him quite a fright. SCARED-RULE STAGE-STAR

*119. The man had been trying to sell his stereo, but he had yet to get an offer he felt he could accept. TAVE

QUESTION: The man was trying to sell his T.V.

120. At night he liked to go outside, lie on his back, and watch the moon. PLANET-BIRD HARVEST-BULLETIN

QUESTION: He liked to look up in the sky.

121. The woman screamed when she saw a large spider crawling up near the top of the wall. CEILING-BEDSPREAD BRICK-CANARY

122. When you play hopscotch, you have to jump around, often on only a single foot. SHOE-CRY BARE-SHEET

123. Jane was having a party so she decided to ask her neighbor if he wanted to come. WENT-PLATE KINGDOM-PEANUT

QUESTION: She invited her neighbor.

*124. For their vacation, the couple decided to go on a month long cruise. MILN

*125. Genghis Khan was known to be a man who was particularly brutal. ALOGE

126. Even though it was fall, the temperature was still quite hot. COLD-WEAR STOVE-JUMP

*127. The man began to have an asthma attack so he quickly took his medicine so that he would be able to breathe. PARL

*128. The college student was disappointed that he didn't know anybody in any of his classes. LICKLE

# Appendix D

## SUBJECT INSTRUCTIONS

Note: this instruction sheet was used for right-handed subjects in the word prime condition. Similar instructions were used for the other condition-handedness combinations.

We are interested in how quickly people are able to recognize words. On each experimental trial, you will first see a fixation point presented in the middle of the computer screen. It is important that you keep your eyes on this fixation point, because during the course of the trial a word will appear at that location. Pairs of words will then be presented to you, one at a time. The first word will be read to you over a set of headphones. You do not have to respond to this first word, but you should pay close attention to it, as it will often help you in responding to the second word. Following this first word, the second word will appear on the computer screen, replacing the fixation point.

When the second word appears, you should pronounce it out loud. The sound of your voice will activate our equipment. The equipment is very sensitive to noises in general, so it is critical that during the course of the experiment you try not to make any irrelevant sounds (e.g., saying things other than the second word, pounding on the table, moving your chair, etc.). Further, it is important that when you pronounce the word you do not precede your response with any irrelevant vocalizations (such as "um" or "ah").

IT IS VERY IMPORTANT THAT YOU PRONOUNCE THE SECOND WORD AS RAPIDLY AS YOU CAN, BUT IT IS ALSO IMPORTANT THAT YOU NOT MAKE ERRORS!

From time to time, following the completion of a trial, a question will be read to you over the headphones. This question will give you a word and will ask you if it was the word that you heard on the trial you had just completed. If it is that word, then you should press the right-most button on the response box with your right index finger. If it is not the word, then press the left-most button with your left index finger.

<<<<<REMEMBER>>>>>

1. Be ready for each trial by keeping your eyes on the fixation point.

2. Pay close attention to the first word, but do not respond to it.

3. When the second word is presented, name that word out loud.

4. Respond as RAPIDLY AS POSSIBLE, while still trying not to make errors.

5. When asked a question, if the answer is "yes" then press the right button. If the answer is "no" then press the left button.

# Appendix E

## INFORMED CONSENT

You are invited to participate in a study of word recognition in which we are trying to learn about the information that people use in identifying words. You were selected because you submitted your name to the UNO Psychology Department as a volunteer.

You will be asked to participate in a single session of approximately 45 minutes. On each trial of this experiment you will be presented with two words. The first word will be read to you over a set of headphones. Following this first word, a second word will appear on the computer screen. Your task will be to pronounce this second word out loud. You will be provided with more detailed instructions for the experiment after completing this form.

There are no discomforts or dangers in this experiment, and no deception is involved. Please be assured that your name will not be involved in any way with the research findings. Please do not hesitate to ask any questions about the study, and remember that even if you initially agree to participate, you are free to withdraw your consent and discontinue participation at any time if you wish. Withdrawl will not in any way prejudice your relationship with the University of Nebraska.

It is recommended that 45 minutes of extra credit be given for this experiment. Of course, participation in this particular experiment is not the only way to earn extra credit in psychology. Other experiments are available during the semester, and other opportunities for extra credit may be discussed with your instructor.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE, HAVING READ THE ABOVE INFORMATION. Thank you very much.

Sincerely,

Robert Peterson

Robert Peterson

____________ date

____________________ Participant's Signature